EPSC Abstracts
Vol. 6, EPSC-DPS2011-788, 2011
EPSC-DPS Joint Meeting 2011

New Elemental Maps of the Nearside Lunar Highlands

J. A. Carter (1), M. Grande (1) and the C1XS Team (2)

(1) IMAPS, Aberystwyth University, Wales, SY23 3BZ. (2) C1XS team will be listed in Acknowledgements.
Contact: jac08@aber.ac.uk

Abstract

A set of elemental maps obtained by the Chandrayaan-1 X-ray Spectrometer (C1XS) and covering the Southern Nearside Lunar Highland region will be presented. The elements mapped will include magnesium, silicon and aluminium, as well as relevant elemental ratios. These will be compared to other datasets including Lunar Prospector, Clementine and M^3 mineral maps.

1. Introduction

In recent years there have been several X-ray fluorescence spectroscopy instruments flown on lunar missions, and in the near future there will be more, both on missions to the Moon and beyond, for instance to Mercury. An X-ray spectrometer instrument can remotely detect the mineralogy of the surface of atmosphere-less terrestrial bodies by recording the X-ray fluorescence caused when the surface is bombarded by solar X-ray events. The Chandrayaan-1 X-ray Spectrometer (C1XS), which flew on ISRO's Chandrayaan-1 mission in 2008, was one such instrument [1].

C1XS had the potential to improve our knowledge of the lunar surface by returning elemental abundances for lighter, rock-forming elements (such as Mg, Al, and Si) at much greater resolutions than previous instrument. At the 100km orbit that Chandrayaan-1 began at, the FWHM spatial resolution was 25 km^2. This was decreased to 50 km^2 when Chandrayaan-1's orbital distance climbed to 200km due to thermal issues mid-way through the mission. These resolutions represent a significant increase on previous maps for these elements.

Chandrayaan-1 flew at a time coinciding with a predicted increase in solar activity. For an X-ray fluorescence instrument, which relies on incident solar X-rays to illuminate the surface, this increase in activity would be enough to guarantee ~100% surface coverage in Mg, Al and Si, and significant areas in Fe, Ti, and Ca. However, the solar cycle was delayed, and instead C1XS launched into the quietest solar conditions seen in 100 years. Regardless, the excellent stability and low noise level of the instrument meant that small flares (A and B class) were able to generate statistically significant findings – these are detailed in the first light paper [2].

A single solar active region generated a (relatively) large quantity of flares during 2009. The coincidental similarity in rotation periods between the Sun and our Moon meant that these flares were largely incident on a single area of the lunar surface – the southern nearside highlands. Figure 1 shows the area in question overlaid with the flare tracks that C1XS recorded.

2. Southern Nearside Highlands

This region broadly covers the area below 10 S latitude and between -10 to +30 E longitude. It has never been the subject of a sample return mission; the nearest ground truth measurements are Apollo 16 at 8.56 S, 15.3 E and Surveyor 7 at 41 S, -11 E – this is mainly due to the uneven, mountainous terrain which makes spacecraft landings hazardous. The region has very high relief, with large slopes and rough surface features – these characteristics complicate the analysis of X-ray fluorescence analysis. It is also covered, for large parts of the area, by rays of Tycho. These rays have been found [3] to be similar in composition to the underlying terrain in both Fe and Ti (from Clementine maps), but they may show more pronounced changes in the lighter elements, and the difference in surface roughness that causes the large albedo differences will also affect X-ray fluorescence to some degree.

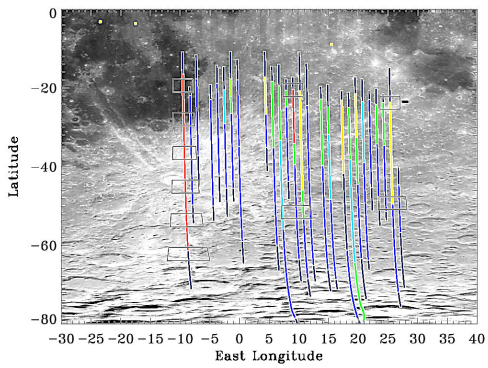

Figure 1: This figure shows the flare tracks that C1XS was able to resolve in the mission lifetime. For analysis of the A-Class flares over the Apollo 14 landing site (in the top left of this figure) see the first light paper [2]. Image Credit: Barry Kellett

Remote sensing has produced maps of some elements for this region. The set of Clementine maps for iron and titanium produced by Lucey [4], and later updated by others (including Gillis [5] – see [6] for a useful summary) show low %wt with little variation over this area. The best resolution maps of Mg, Al and Si published so far are the mineralogical maps of their oxides presented in Prettyman 2006 [7] which were derived from Lunar Prospector data: these maps cover the region in question with only a few pixels; the C1XS results are better resolved.

New and upcoming datasets, such as those from the M^3 instrument on C1XS, [8] will also produce results in this area, including elemental and mineralogical values. It will be crucial to compare C1XS data to these results to ensure consistency and context for our methodology.

One flare track was studied in this region by (Narendranath S., et al.) [9] – this study will expand on their work and generate a map of the entire area (see fig. 1).

3. Results

Maps of the area described above, will be presented. These will include elemental amps of Mg, Al and Si, and maps of MgO/SiO_2 Al_2O_3/SiO_2 for direct comparison with Lunar Prospector maps. A discussion of the Ti and Fe values found will be presented, to the extent possible given the prevailing low solar conditions.

References

[1] Grande M. et al.: The C1XS X-ray spectrometer on Chandrayaan-1. Planet. Space. Sci., 2009.

[2] Weider, S.Z., et al.: The Chandrayaan-1 X-ray Spectrometer: First Results. Submitted to Planetary and Space Science, 2011.

[3] Carter, J.A., et al.: Factors Influencing Lunar Surface Analysis Using XRF. Proc. Lunar Sci. Conf. 42, 1819. 2011.

[4] Lucey et al.: Lunar iron and titanium abundance algorithms based on final processing of Clementine ultraviolet-visible images, JGR, Vol.105 No. 8, 2000.

[5] Gillis et al.: Global concentrations of Th, K, and FeO as derived from Lunar Prospector and Clementine data, Geochimica and Cosmochimica, Vol. 68, No. 18, pp. 3791-3805, 2004.

[6] Weider, S.Z., et al.: Individual lava flow thicknesses in Oceanus Procellarum and Mare Serenitatis determined from Clementine multispectral data, Icarus, doi:10.1016/j.icarus.2010.05.010, 2010.

[7] Prettyman, T.H., et al.: Elemental composition of the lunar surface: Analysis of gamma ray spectroscopy data from Lunar Prospector. JGR, Vol.111 E12007, 2006.

[8] Pieters CM,. et al.: The Moon Mineralogy Mapper (M-3) on Chandrayaan-1.Current Science Vol.94 Iss 4 pp.500-505. 2009.

[7] Narendranath S., et al.: Lunar X-ray fluorescence observations by the Chandrayaan-1 X-ray Spectrometer (C1XS): Results from a lunar highland region. In press, doi:10.1016/j.icarus.2011.04.010

Acknowledgements

The C1XS Team:
M Grande, A Cook, JA Carter (Aberystwyth University, UK), BJ Maddison, BJ Kellett, CJ Howe, BM Swinyard (STFC, RAL, UK), P Sreekumar, A Shrivastava, S Narendranath (ISRO, India), J Huovelin L. Alha (Helsinki Univ, Finland), IA Crawford, SZ Weider (Birkbeck College London, UK), KH Joy (LPI, USA) CL Duston, O Gasnaut, S Maurice (CESR, Toulouse, France), D Smith (Brunel Univ, UK), D Rothery, M Anand, A Holland, J. Gow (Open University, UK), SS Russell (Natural History Museum, K), JN Goswami, N. Bhandari (PRL India), D Lawrence (Los Alamos National Lab, USA), V Fernandes (Museum für Naturkunde, Berlin), T. Okada (ISAS, Japan), C Erd (ESTEC,ESA), D Koschny (ESTEC), C Pieters (Brown University), M Wieczorek (IPG, Univ Paris Diderot).